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# *metrics

## RECOMMENDATIONS FROM THE DFG *METRICS PROJECT FOR “MEASURING THE RELIABILITY ANDPERCEPTIONS OF INDICATORS FOR INTERACTIONS WITH SCIENTIFIC PRODUCTS”

DINI Schriften 19-en | Version 1.0 | December 2020

DEUTSCHE INITIATIVE FÜR NETZWERKINFORMATION E. V.

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Die Onlineversion dieser Publikation finden Sie unter:
DOI: 10.18452/22242

DINI Schriften 19-en
[Version 1.0, Dezember 2020]

# Content

## About DINI

The development of modern information and communication technologies is driving change in the information infrastructures of higher education institutions and other research institutions. This change has a sweeping impact on higher education in Germany, in turn requiring more agreements, cooperation, recommendations, and standards than ever before. The Deutsche Initiative für Netzwerkinformation (DINI, German Initiative for Network Information) supports this development.

DINI was founded to advance the improvement of the information and communication services, and the necessary development of the information infrastructures at universities as well as on regional and national levels. Agreements and the distribution of tasks among the infrastructure institutions and facilities can significantly extend the range of information technology and services. This gives rise to the need for the joint development of standards and recommendations.

DINI is an initiative of three organizations:

- AMH (Arbeitsgemeinschaft der Medienzentren der deutschen Hochschulen; Consortium of German University Media Centers),
- dbv (Deutscher Bibliotheksverband Sektion 4: Wissenschaftliche Universalbibliotheken; German Library Association, Section 4: Academic Universal Libraries),
- ZKI (Zentren für Kommunikation und Informationsverarbeitung in Lehre und Forschung e. V.; Association of German University Computing Centers).

DINI has the following goals:

- Publicize and recommend best practices;
- Encourage and support the formulation, application and further development of standards as well as distribute recommendations regarding their application;
- Register and advertise Competence Centers using modern web-based technologies;
- Improve interdisciplinary exchange through congresses, workshops, expert conferences, etc.;
- Advertise new funding programs and encourage new programs.

# 0. Purpose of publication and intended readership

This publication results from our joint research project "*metrics - MEasuring The Reliability and perceptions of Indicators for interactions with sCientific productS"[1], conducted from 2017 to 2019 and funded by the German Research Foundation, the DFG. The project was supported by the DINI Electronic Publishing Working Group throughout the project period, with the project results discussed among members of the working group.

The project had four major goals that guided our research. First, the project aimed to describe popular and major social media platforms and their functionalities, e.g. retweets or likes. They represent the environment in which engagement with scholarly output takes place, thus forming the basis for the setup of and research on altmetrics (see "Maintain a register of social media platforms" in Chapter 7 "Recommendations from *metrics project"). Second, the project should highlight the characteristics of, and differences between, users of social media platforms and the platforms' functionalities. Why do they use certain functionalities and what for? To this end, we studied explicit user (group) behavior as revealed in surveys and interviews (see Chapter 2 "Perception of *metrics in the research community"). In addition, we analyzed implicit user behavior gleaned by tracking users' interactions with scholarly outputs (see Chapter 3 "Reliability of altmetrics"). How researchers perceive and use altmetrics in working routines was studied in a third focus area of the project by asking directly in surveys or by revealing implicit user preferences via online experiments. Those studies informed research in terms of perceived value, validity and reliability of altmetrics, and whether altmetrics can adequately assess scholarly outputs (see Chapter 3 "Reliability of altmetrics"). A fourth work package completed the research by investigating the technical issues surrounding the setup of altmetrics, in turn affecting their use, perception and reliability. Moreover, we provided solutions for tackling data acquisition challenges (see "*Metrician" in Chapter 5 "Tools and services").

1 https://metrics-project.net/



This publication includes both novel insights from our own project results and references to the broader existing state of literature in the field of altmetrics. As altmetrics research is closely tied to an ecosystem of tools used to access specific types of data based on user-generated content, we will also cover questions related to overseeing current access options and tools for using altmetrics data. We will conclude with recommendations for users and stakeholders of altmetrics when deciding whether and how to use *metrics in various settings.

We hope that this publication will be useful for several groups of potential readers. We recommend it to anyone with a general interest in learning about different types of *metrics as a means of measuring academic performance and scholarly communication, and about social media metrics in particular. More specifically, we believe that our work will be useful for the different actors affected by all types of *metrics in their working environment. This includes, but is not limited to, the following groups:

- *Researchers*: As subjects of evaluation, researchers should have a general understanding of how evaluation is carried out, and what the limitations and effects of current approaches may be. They may also be interested in how to collect information about their own performance based on different types of *metrics, and compare themselves to other (similar) researchers or showcase their research.
- *Research administrators*: Anyone already using bibliometric data to produce assessments or rankings in institutional contexts may want to stay informed about additional options and current standardization efforts in the field of altmetrics, and the practical challenges involved in producing the data on an individual or institutional level.
- *Funders*: Funding agencies which have previously used elaborate review processes to make funding decisions may now want to know if there are indicators that are similarly effective for their decision-making processes. A key question for funders may also be whether altmetrics really have the potential to indicate societal impact of scholarly outputs.

- *Librarians:* (Research) librarians usually know about the importance of bibliometric data, but may want to learn more about alternative metrics and their relevance, in particular how altmetrics can be assessed and whether they are important for researchers.
- *Repository managers:* For some repositories, altmetrics may appear to be useful indicators for navigating or ranking collections, and some repository managers may have already experimented with commercial services for adding altmetric data. This publication will answer potential questions about the validity of the aggregated data, possible data sources of altmetrics and their quality, and how altmetrics can be implemented in repositories from a technical perspective.
- *Publishers:* Publishers of both academic journals and books might be interested in tracking their own products by way of different *metrics. They may want to keep informed about alternatives to the Journal Impact Factor, engage with their audiences through social media and track their authors' relevance, both in academia and broader societal discussions.

All of these stakeholders are affected by the changing nature of available sources for measuring scholarly impact, and by the ongoing discussions on use cases and best practices, also in light of the international open science movement (Wilsdon et al., 2017). While in many areas scholarly impact is mainly deemed to be represented through the Journal Impact Factor (JIF), the uncritical use of this single metric beyond its intended use is frequently called into question (by, among others, Hicks et al., 2015). Some funding calls and evaluations may now also ask for additional evidence, e.g., of the societal relevance of research outputs (see, for example, the British Research Excellence Framework).

We want this publication to encourage critical thinking about how scientific communities and the general public may be interacting in new ways with research output in online environments and on social media. We also urge critical thinking about new ways of evaluating research work, in particular by deciphering the proposition that *metrics can (and sometimes cannot) deliver. Our aim here is to encourage all stakeholders to constantly reflect on any *metrics in use, and to be aware of their production, scope, limitations and expressiveness (see Chapter 7 "Recommendations from *metrics project").

This publication follows in the vein of notable resources that have been published before, such as:

- "Outputs of the NISO Alternative Assessment Metrics Project. A Recommended Practice of the National Information Standards Organization" (NISO, 2016),
- "Altmetrics for information professionals: Past, present and future" (Holmberg, 2015),
- "Altmetrics for Librarians: 100+ tips, tricks, and examples" (Konkiel, Madjarevic & Rees, 2016),
- "Altmetrics: A practical guide for librarians, researchers and academics" (Tattersall, 2016), or
- "The Leiden Manifesto under review: what libraries can learn from it" (Coombs & Peters, 2017).

However, this publication is also unique in that it focuses on target-group-specific analyses, i.e., economists and social scientists, and examines more directly the usage and perception of altmetrics. Hence, this publication answers questions on the validity and reliability of altmetrics as well as their perceived usefulness. Recommendations include advice for institutions as well as wider considerations for research assessment in general and ways forward at a national level.

# 1. Introduction to *metrics

Measuring academic productivity and scholarly communication is a practice that has been carried out for decades and scientifically reflected in bibliometrics and scientometrics research (Glänzel, Moed, Schmoch, & Thelwall, 2019), with indicators based on measuring publication output and citation counts as traditional approaches. Indicators such as the Journal Impact Factor2 (JIF or IF) have most prominently been used to compare researchers' performance and judge academic productivity and impact, while also enabling new options for searching and exploring publication lists (e.g. searches based on cited references). New approaches are constantly being discussed in the field of scientometrics (Cronin & Sugimoto, 2014). In addition to established and new indicators based on publication and citation counts, alternative indicators have been explored in more recent years. These alternative sources for measuring scholarly communication may be based on web links or download numbers (as introduced under the term "webometrics" [Thelwall, 2008]), or on a variety of formats involving user-generated content and social media environments. The term "altmetrics" (Priem et al., 2010) has become popular when referring to the broad spectrum of counting social media activities for measuring academic output.

In the following text we will use the truncated form *metrics to summarize all of the different approaches involved in measuring scholarly communication, irrespective of whether they would normally be classified as traditional bibliometrics / scientometrics, or as more recent webometrics / altmetrics approaches. However, in this publication we mainly focus on the more recent approaches involving social media data or other data from user-generated web content as the underlying data source. We will use the terms altmetrics, alternative metrics and social media metrics for these approaches interchangeably (as all of these terms are currently applied in the literature and the research community).

2 http://clarivate.libguides.com/jcr



Altmetrics embrace the broad spectrum of activities that connect users of social media platforms with scholarly communication. In many cases, this means that scientific publications are being mentioned on social media platforms, e.g., a tweet mentioning a new journal article, a Facebook post summarizing a conference paper, or a book referenced in a Wikipedia article. Researchers can use social media platforms such as Twitter or Mendeley to retrieve interesting literature and to promote their own work. A general public audience may learn about research findings by interacting with social media and, at least theoretically, has the opportunity to directly interact with them, e.g., by commenting on social media posts.

Alternative metrics based on social media data arrived in the field of traditional metrics with some remarkable initiatives, most notably condensed in the "Altmetrics Manifesto" (Priem et al., 2010). All types of *metrics come with a variety of challenges, constraints and pitfalls. While traditional indicators based on citation counts have been criticized for various reasons (for a recent example, see DORA3), altmetrics were envisioned to solve at least some of these challenges. For example, altmetrics based on social media data are far quicker to react to scientific findings; while it may take years before a publication is formally cited, it can be mentioned on Twitter, Facebook and other platforms within minutes of being published. Thus, "social media mentions being available immediately after publication—and even before publication in the case of preprints—offer a more rapid assessment of impact" (Thelwall et al., 2013). Piwowar (2013, p. 9) outlined the following four advantages of altmetrics: They provide "a more nuanced understanding of impact", they provide "more timely data", they include the consideration of alternative and "web-native scholarly products like datasets, software, blog posts, videos and more", and they serve as "indications of impacts on diverse audiences".

3 San Francisco Declaration on Research Assessment (DORA): https://sfdora.org/

Nonprofit and for-profit organizations including publishers or academic social networking platforms were quick to take up on the idea of altmetrics. Here, results include products such as the so-called "Altmetric donut" and the "ResearchGate score", both of which are described in more detail in Chapter 5 "Tools and services".

The different visions where altmetrics enrich current indicators and measure alternative types of impact were also accompanied by a new research branch to investigate the nature of altmetrics. The early history of altmetrics research is summarized, for example, by Fenner (2014). Scholars from different backgrounds, but prominently including researchers from library and information science with experience in scientometrics research, acted as pioneers in developing research approaches to gain a better understanding of the nature of altmetrics and the link between social media and scholarly communication. Topics pertaining to altmetrics research can be found at established scientometrics conferences (e.g., ISSI[4]) or journals (e.g., Journal of Informetrics, Scientometrics, Journal of Altmetrics), at specialized events and workshops (e.g., the AM Conferences[5] or the altmetrics-workshop series[6]), but also as parts of events focusing on internet-related research topics in general (e.g., ACM Web Science Conference[7], International Conference on Computational Social Science[8]).

4 http://issi-society.org/conferences/

5 http://www.altmetricsconference.com/

6 For example: http://altmetrics.org/altmetrics18/

7 For example: https://websci19.webscience.org/

8 For example: https://2019.ic2s2.org/



Much of the early research into altmetrics focused on outlining the quality and scope of altmetrics indicators, especially in comparison to more traditional indicators, e.g., citations. Frequent research approaches involve studies comparing *metrics across platforms (either alternative or traditional; Chamberlain, 2013; Zahedi & Costas, 2018) or investigating performance or participation in social media of scholars across various disciplines (such as Mohammadi & Thelwall, 2014; Zahedi, 2018). Another common research question is whether social media mentions predict subsequent citation rates or, at the very least, correlate to some degree with traditional metrics. A notable example of a comprehensive comparison of altmetrics and citations is the work by Thelwall et al. (2013). The authors looked at 11 different social media resources and found they could not predict subsequent citations, suggesting that altmetrics may indeed measure a form of impact other than citations. However, other studies have arrived at different conclusions, tracing forms of correlations or predicting citations from altmetrics (e.g., Eysenbach, 2011). These different results indicate that more work is needed in order to fully understand the nature of user behavior in social media environments and the value of individual metrics obtained by measuring this user behavior (Zahedi, 2018). Various factors influence the exact nature of altmetrics, including the following at the very least:

- the diversity of online platforms that can be considered as social media, thus contributing to the altmetrics spectrum, and the different ways that each platform allows users to create and engage with content,
- the different access points to collect altmetric data (e.g., through public APIs[9]) and the restrictions imposed on data collection,
- the diversity of the research community, especially related to disciplinary differences in citation and communication practices or related to the presence of different academic groups (e.g. students, junior researchers, professors), on different social media platforms,
- additional and external factors that influence visibility and accessibility of academic publications which interact with *metrics in different

9 Application Programme Interface

ways (e.g., open access publications perform differently to closed-access publications)

All of this can be considered in view of the underlying and surrounding settings on and in which the *metrics project took place and steered our work. The project's main objective was to develop a deeper understanding of *metrics, especially in terms of their general significance, validity and reliability as well as how they are perceived by stakeholders. Findings gleaned from such research facilitation informed use of altmetrics, taking into consideration their limitations and opportunities for interpretation.

In view of this, the project's findings can aid the "interpretation of 'altmetrics' digital traces" (Xu, 2018) and answer the call for more research on the challenges posed by altmetrics. Here, challenges include heterogeneity such as the diversity of the actors and actions on social media platforms, data quality such as lack of accuracy, consistency and replicability, and particular dependencies such as the availability of APIs and digital object identifiers (DOIs[10]) (Haustein, 2016).

In this publication we will present the outcomes of the project by first describing *metrics' ability to adequately assess scholarly outputs against the background of disciplinary specificities and user perceptions (see Chapter 2 "Perception of *metrics in the research community"). Then we will report on studies surrounding the contexts in which altmetrics arise and their impact on the interpretation of altmetrics. We will also discuss the other factors that have an impact on altmetrics and also affect their reliability (see Chapter 3 "Reliability of altmetrics"). Next, we will address the quality of altmetrics' underlying data and the consequences of data gathering and the technical implementation of altmetrics (see Chapter 4 "Practical challenges when collecting altmetrics data").

After that, in Chapter 5, we will provide an overview of "Tools and Services" that provide altmetrics data, and we will introduce an altmetrics aggregator developed in our project, the "*Metrician". Then we will describe use cases in which altmetrics have been proven to add value to current applications of *metrics (see Chapter 6 "What are altmetrics already good for?"). We will present recommendations for stakeholders of *metrics that have been derived from *metrics literature as well as from outcomes of the *metrics project (see Chapter 7 "Recommendations from *metrics project"). Finally, we will offer general "Conclusions" in Chapter 8 and an outlook on future *metrics' use.

10 See details here: https://www.doi.org/factsheets/DOIIdentifierSpecs.html



## 2. Perception of *metrics in the research community

As the vision of using altmetrics promises a variety of benefits, and as new opportunities are being discussed among experts in *metrics, the question arises as to how these opportunities are perceived among the broad community of researchers whose activities the metrics are supposed to evaluate.

In the following chapter we will summarize key findings from different studies on the perception of *metrics among researchers (see also Sugimoto et al., 2017). The user studies conducted in the *metrics project consisted of four segments:

1. An initial explorative large-scale online survey, conducted in 2017, to determine the status quo of researchers' use of social media platforms from which altmetrics are derived;
2. A series of in-depth group interviews with researchers to investigate their perceptions of scholarly use of social media as well as of various metrics for research evaluation;
3. A second large-scale online survey, conducted in 2018, with the aim of examining the extent to which findings from the interviews are applicable to the larger population of researchers;
4. An interactive experiment with the goal of finding out how researchers are influenced by different quantitative metrics when assessing the relevance of individual research articles.

This chapter summarizes central results from segments (2) to (4) on researchers' perception of *metrics, while segment (1) - our first online survey, chronologically speaking - will be discussed further in the Chapter 3 "Reliability of altmetrics". Information on respondents' demographics during all four segments can be found in this publication's appendix.

As the group interviews with researchers have shown, when confronted with the terms "metrics for scientific impact" or "metrics for research evaluation", many of them were completely unfamiliar with the concept of using web-based metrics (i.e., usage metrics or altmetrics) for assessments of this kind (Lemke, Mehrazar, Mazarakis, & Peters, 2019). Conversely, bibliometrics in the form of JIF, citation counts, or h-index were widely known across the interviewed groups, whilst the concept of academic rankings seemed to be fairly common among economists. In line with this, the interviewed researchers often stated that they used citation counts or a publishing journal's IF as a basis for determining whether a newly retrieved research article might be worth reading.

Moreover, the *metrics project's second survey from 2018 showed that 86% and 76% of the participating researchers described citation counts and the publishing journal's IF, respectively, as being a "useful" or "very useful" tool for assessing the relevance of output. By contrast, for the ten web-based metrics asked about in the survey, the corresponding response levels were considerably lower: apart from download counts, which 62% said were either useful or very useful, for all of the other metrics the number of users who found them useful did not exceed the number who found them "hard to use" or even "useless" for such assessments (Lemke et al., 2019; see also Figure 1).



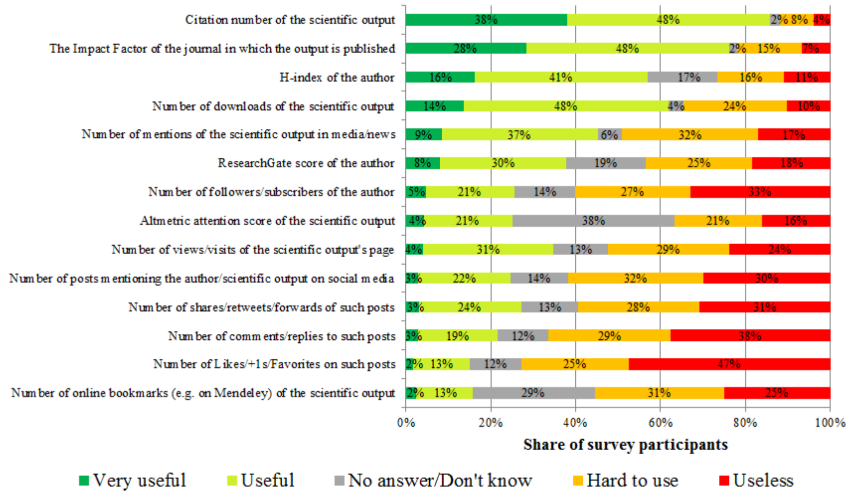



Figure 1: Perceived usefulness of different types of *metrics for researchers (Lemke et al., 2019).

The prevalence of such a preference order between *metrics among researchers was also backed up by the results of an interactive experiment (Lemke, Mazarakis, & Peters, 2020) in which 247 participating researchers were given very limited information and then asked to rank sets of fictitious research articles in terms of expected relevance (see Figure 2 for an example of such a ranking task). For every fictitious article, only six *metrics were displayed: the article's citation count, its download count, its number of mentions on Twitter, its number of bookmarks on Mendeley, its publishing journal's IF, and its first author's h-index. During the experiment's planning process we decided to include a maximum of six metrics so participants would not be overloaded with too much information at once (see also McCullough [2002]); these particular six indicators were then chosen so participants could potentially base their decisions on an article-level bibliometric, a journal-level metric, an author-level metric, a more research-related altmetric, a more public-related altmetric, and a usage metric.

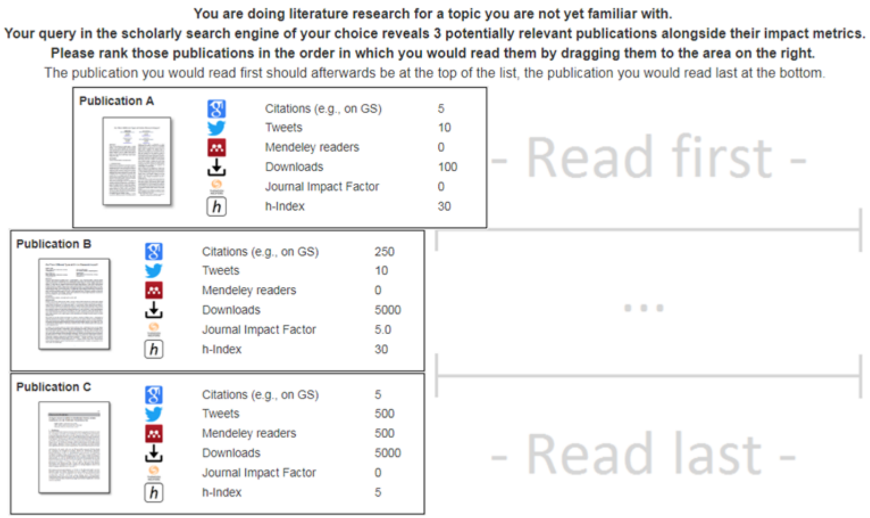



Figure 2: Example of a task from the interactive ranking experiment.

The participants' ranking orders were fed into a logistic regression model to estimate the individual *metric's impact on an article's likelihood to get ranked higher than its competitors. While the model showed a significant positive relationship between the value of each of the six indicators and an article's likelihood of getting ranked highly, the comparison of the indicators' individual influences largely confirmed the findings of the qualitative interviews and the 2018 survey into researchers' preferences in *metrics: the strongest influence on ranking decisions were citation counts and journal IFs, followed by download counts, h-index, Twitter mentions, and Mendeley bookmarks. Moreover, when subsequently asked which one of the six indicators the participants would find most helpful when deciding which articles to read, the vast majority of participants chose either citation counts (60%) or JIF (27%), with zero participants opting for the altmetric representatives, i.e. tweets or Mendeley bookmarks.



As the regression model had nevertheless shown that both Twitter mentions and Mendeley bookmarks are significant predictors for an article being perceived as potentially relevant, this result may indicate that some researchers use altmetrics in conjunction with the other *metrics, e.g. as 'tiebreakers', but not on their own. In view of this, researchers would not consider using altmetric counts as their first and only filter during literature search, yet they may still draw upon them if their preferred filters do not provide a clear result.

While interviews, surveys and experiments all indicate that *metrics - especially in the form of bibliometrics - play a significant role for many researchers when determining relevance, the responses gathered in these user studies also showed that researchers are not free of concern regarding the use of *metrics (Lemke et al., 2019). Frequently stated concerns include a perceived lack of transparency, the assumption that *metrics are only able to measure popularity rather than relevance or quality, and their susceptibility to manipulation and gaming. All in all, researchers' perceptions of *metrics often seem to be highly ambivalent: bibliometrics in particular are deemed to be a helpful tool many researchers regularly make use of despite their vague awareness of the fact that they can easily be misapplied and misinterpreted. These observations are in line with findings by Hammarfelt & Hadow (2018) who analyzed Australian and Swedish humanities researchers' attitudes towards bibliometrics. They found these scholars' attitudes towards bibliometric indicators to be mixed, with many researchers "critical of these measures, while at the same time feeling pressured to use them".

# 3. Reliability of altmetrics

The concept "reliability" is used to describe the extent to which a measure produces similar results under consistent conditions and, therefore, can make claims on the reproducibility of results. In the case of altmetrics, the fact that they are, to a large extent, derived from interactions on social media platforms leads to questions about how, for example, the latter's sensitivity to controversial topics and particular real-world events might affect their reliability. Further issues regarding altmetrics' reliability could result from their deeply heterogeneous origins. The signals measured as altmetrics happen on a variety of online platforms which can vastly differ regarding their affordances, functionalities, prevalent modes of communication as well as topics and other characteristics (Lemke & Peters, 2019). Also, the varying degrees with which different user groups are represented by different kinds of altmetrics have an influence on their meaning. Even beyond the involved platforms and actors, the individual types of interactions that are themselves counted as altmetrics emerge under deeply heterogeneous circumstances and express substantially different things. For example, a mention of a research article in a blog post probably indicates a considerably higher level of engagement with the article than a mere download of its PDF file (see also Haustein, Bowman, & Costas, 2016). To be able to accurately evaluate the reliability of altmetrics, thorough examination of these various layers is required to determine the ways in which they shape altmetrics' multifaceted manifestations.

In *metrics research it has been shown that Mendeley reader counts and F1000 reviews can be used as reliable and valid measurement instruments of research assessment and paper quality (Bornmann, 2015; Thelwall, 2018; Zahedi, Costas, & Wouters, 2018). Moreover, tweet counts (Finch, O'Hanlon & Dudley, 2017; Thelwall et al., 2013), number of Wikipedia articles (Kousha & Thelwall, 2017), number of blogs that mention scientific publications (Shema, Bar-Ilan & Thelwall, 2014; Thelwall et al., 2013), page views and paper downloads from publisher web sites (De Winter, 2015) were contrasted with citation counts to test their proxy to scientific impact.



However, altmetrics research to date has largely involved the validity (the degree to which a tool measures what it claims to measure) of the diverse forms of altmetrics, such as Wikipedia citations or Twitter tweets, when compared to more traditional forms of *metrics, such as citations. At the same time, the reliability of most altmetrics has not been studied exhaustively.

Thus, we conducted several experiments and surveys to take initial steps towards assessing altmetrics' reliability by testing their consistency:

1. across different researchers, e.g., in terms of user groups and motivations represented by individual altmetrics (see section "Effects of user behavior on altmetrics' meaning"),
2. across items, i.e., their internal consistency (see section "Consistency across altmetrics"), and
3. over time (see subsection "Dynamics").

With regard to (1), we studied the possible implications of altmetrics' meanings resulting from the divergent ways in which researchers use the heterogeneous online platforms from which altmetrics are derived. With regard to (2), article-inherent factors, factors outside the article, altmetrics' data quality and its dynamics were studied as potential influencers of stability and consistency (i.e., attributes of reliability). To test (3), one has to rely on high-quality datasets with timestamps. As a result of the project, we created two relevant datasets: (social) media mentions of publications from our projects' aggregating tool, the *Metrician (see section "*Metrician" in the Chapter 5 "Tools and Services"), and history of Wikipedia references (see subsection "Dynamics").

In the upcoming sections we will summarize the main findings gleaned by following these approaches.

## 3.1 Effects of user behavior on altmetrics' meaning

In this section we will report on findings from our user studies (see also Chapter 2 "Perception of *metrics in the research community") that revealed how user behavior on online platforms can affect respective altmetrics' explanatory power. It should be noted that some of the analyses reported in this section also partially refer to altmetrics' *internal consistency*, which will be examined in the following section "Consistency across metrics". Nevertheless, all of the analyses presented here are related to questions about how user behavior shapes altmetrics' meaning and are therefore reported as one coherent section.

Insights into how altmetrics are affected by divergent ways of using the heterogeneous platforms they are derived from were provided by the responses to the *metrics project's first survey (see Lemke et al. [2017] for an overview). In this survey, ~3,400 participants reported on their typical frequencies of interacting with research products online, e.g., by downloading or bookmarking research articles, by mentioning them in postings on social networks, or by commenting on, sharing, or liking such postings about academic research. In total, 107 such individual actions had been implemented in the survey. By way of example, Figure 3 shows the frequencies with which users interacted with research products via the four actions available on Facebook that were included in our survey.



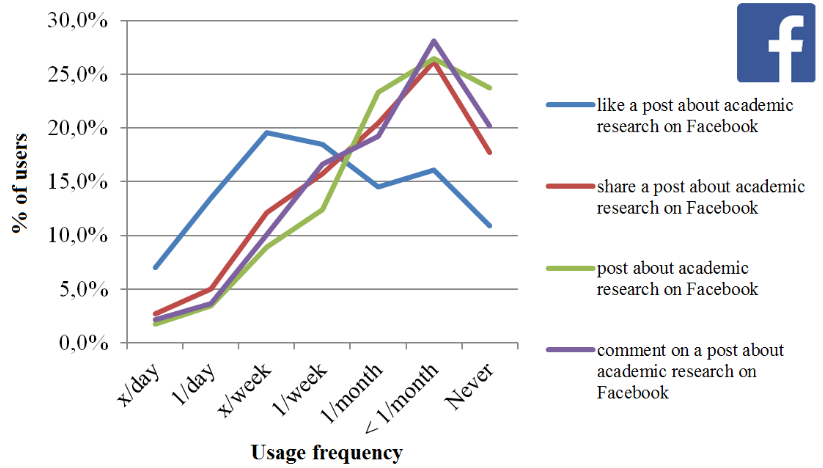



Figure 3: Users' frequencies of interacting with research through four actions provided on Facebook.

Comparing the reported frequencies for individual ways of interacting with research online also revealed how certain types of altmetrics may be better suited to reflecting the attention research receives among different parts of the academic community (Lemke, Mehrazar, Mazarakis, & Peters, 2018; see also Mehrazar, Kling, Lemke, Mazarakis, & Peters, 2018). Analogous to Figure 3, Figure 4 shows how interaction frequencies for the four Facebook actions vary between the group of early stage researchers (i.e., PhD candidates and research assistants) and the group of professors.

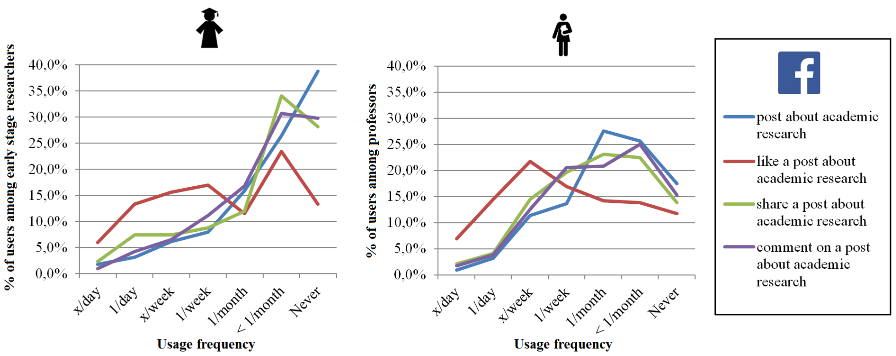



Figure 4: Research roles' (professors (left) and early stage researchers (right)) frequencies of interacting with research through four actions provided on Facebook.

Looking across the entirety of platforms included in our survey, early stage researchers tend to frequently download and bookmark research outputs from various kinds of platforms. Professors more frequently engage in several actions involving the creation of original texts about academic research, e.g., writing posts that mention scientific products on social networks such as Facebook or Twitter (Lemke et al., 2018). Regarding the interpretation of according altmetrics, this suggests that download counts will tend to reflect research used by early stage researchers, whereas counting mentions of scientific products on Twitter will lead to values that are likely to more strongly reflect which research more experienced scholars paid attention to.

Other differences between types of altmetrics that are relevant for their adequate interpretation result from the motivations with which the underlying actions are performed (see also Haustein et al., 2016). When a metric is interpreted as an indicator of scientific relevance, the implicit assumption is often such that the interactions measured via the metric reflect a positive stance on the referenced object, e.g., by expressing validation or approval. To examine how homogeneously different types of



altmetrics behave in this regard, participants of the *metrics project's first survey were also asked to estimate in how many cases their different ways of interacting with research online are meant to reflect such a positive stance (Lemke et al., 2018). Participants were asked to select a response on a 4-item ordinal scale ranging from 'never' to 'in all cases' for each single action they had previously identified as having used. Of the 42 actions, for which we gathered more than 150 individual responses, Figure 5 shows the percentage of users of each specific action that reported to have exclusively used it to express a positive stance of its target (with each diamond representing one action). This way, for example *likes* across various online platforms could be identified as fairly reliable indicators of approval, while *comments* appear to be the least reliable web-based indicator type in this regard. Only very few researchers (14-17% per platform) stated that their comments on research online are 'in all cases' meant to express approval of the respective research output. In other words, an altmetric that counts the number of mentions of a research output in online comments will probably incorporate a larger share of either critical or neutral engagements than an altmetric that only counts the number of likes. Moreover, in some cases, even altmetrics resulting from the same type of action may behave very differently in this regard depending on the platforms we compare, suggesting that similar actions are used on different platforms for different purposes. For example, a 'like' on LinkedIn is not generally meant positively by as many of its users as a 'like' on YouTube (see Figure 5).

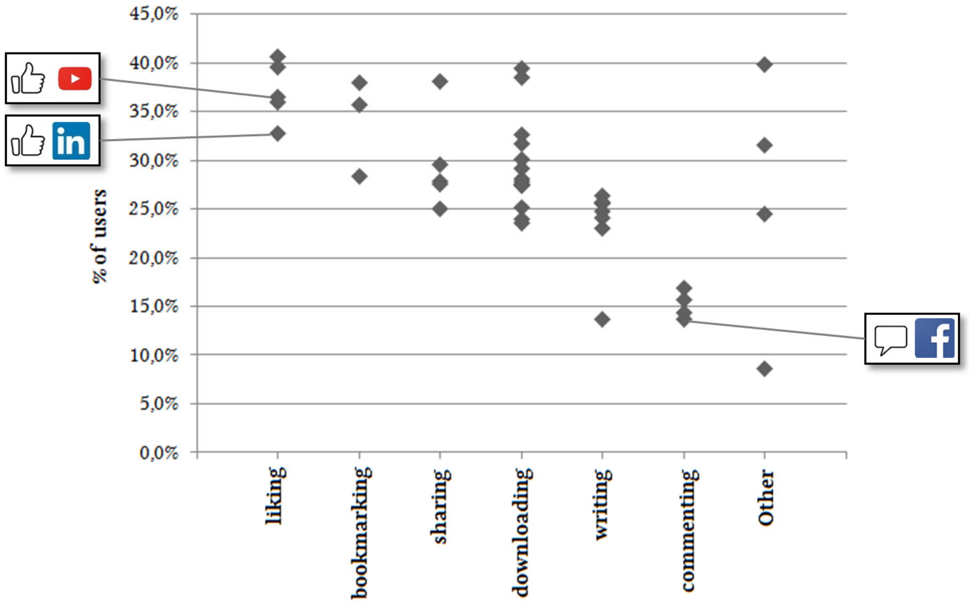



Figure 5: Positivity of actions across platforms' functions; the three tiles serve as examples (Lemke et al., 2018).

Inspired by the results from the surveys in which participants did not consider their own comments on research-related social media content to typically reflect a positive stance towards the referenced content, we decided to look into this on the basis of actual data from social media platforms. To estimate the actual share of negative assertions among online comments towards research-related content, we conducted a sentiment analysis study (Zagovora et al., 2018b). We calculated polarity and subjectivity of more than 4.5 million comments on posts that link to scientific publications on four (social) media platforms, namely YouTube, Google+, Reddit and (comments on) PLOS. With this approach we found that fewer than 14% of comments express a negative opinion across all the platforms.

According to our studies (Zagovora et al., 2018b; Zagovora & Weller, 2018), most comments on social media content relating to research publications were either neutral or positive. Around 7% of YouTube videos, 12% of PLOS publications and Google+ posts, and 14% of Reddit posts were classified as content (mostly comments) with negative communication (Zagovora et al., 2018b; see also Figure 6). Since it was not clear from this automatic sentiment analysis at whom or what that negativity was aimed, we performed additional manual analyses of extremely positive and extremely negative conversations around YouTube videos (Zagovora & Weller, 2018). This revealed three recurring objects of negativity for our specific collection: (1) topics and videos that would raise feelings of disgust among the audience, (2) controversial or radical topics (such as terrorism and vaccines), and (3) controversies about health and nutrition topics. In most cases, negative sentiments were expressed towards the YouTube video itself and did not indicate criticism of the scientific papers referenced in the video.

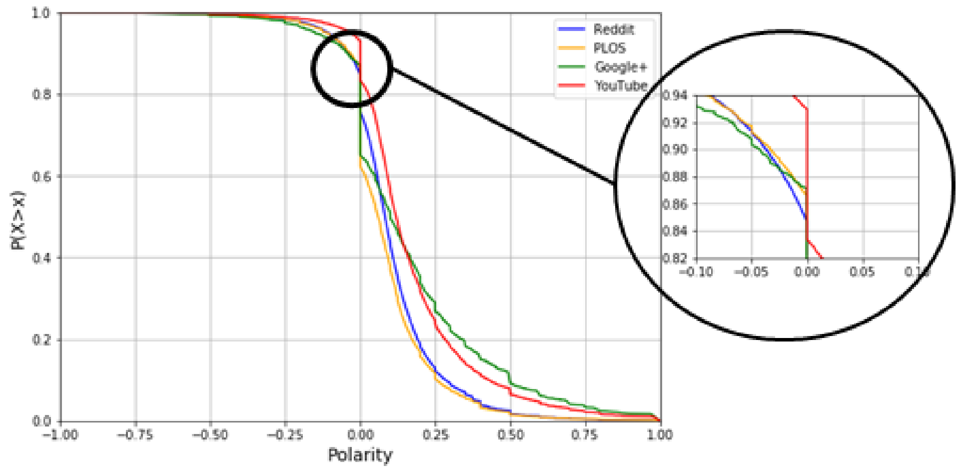



Figure 6: What is the percentage of posts that are not negative?

Conversely, we found that comments classified as highly positive were addressed towards: (1) the presenters for their efforts in sharing topics from everyday life and lifestyle, (2) video bloggers due to being informative in explaining or visualizing scientific topics or scientific papers, (3) scientists due to the informative value or general importance of their research. In other words, despite the existence of negative opinions expressed in YouTube comments, there was no evidence of highly negative expression or striking criticism towards scientific outputs, research or scientists. One has to bear in mind, however, that objective criticism can be conveyed by means of neutral language, which might not be picked up by automatic sentiment classification methods. We did find cases of (likely non-academic) YouTube users who were actively engaging with scholarly publications in their videos and  received praise for this in the video comments. This is indeed a form of "alternative" interaction with research output that can be considered as having an impact on a broader public scale, in turn making it a starting point for investigating more cases of reflections on scientific outcomes beyond core research communities.

To conclude, comment counts and sentiments on YouTube may be deemed an initial indicator of public appreciation of or public engagement with scholarly topics (see Chapter 6 "What are altmetrics already good for?") that influence everyday life, but seem less suitable for measuring the expression of a positive stance towards a scholarly publication.

Besides providing information that may be useful in creating indicators tailored to research impact, analyses like these illustrate the kinds of latent difference between different types of altmetrics, which may seem to be interchangeable at first glance. These examples hint at the large potential altmetrics have to paint a very nuanced and varied picture of the attention scholarly products receive. They also illustrate the problems encountered when aggregating altmetrics from diverse sources into simple scores, e.g., the Altmetric Attention Score from Altmetric.com, as such practices will inevitably obscure said differences.



## 3.2 Consistency across altmetrics

The second type of reliability is internal consistency, or consistency across items, the extent to which all of the items of measurement (i.e., altmetric counts) assess the same latent variable (e.g., scientific impact). To check altmetrics consistency across items, we considered the following factors: data quality, article-inherent factors, factors outside the articles, and dynamics of altmetrics. All of these groups of factors have been studied separately and are described in the following section.

Multiple studies have shown that the correlation between classical bibliometrics indicating scientific impact and altmetrics varies by discipline (Haustein, 2016; Costas et al., 2018; Zagovora et al., 2018a; Zahedi & Haustein, 2018) and altmetric type (De Winter, 2014; Haustein, 2016; Peoples et al., 2016; Thelwall et al., 2013; Zagovora et al., 2018a). For instance, tweets may help to predict citations in ornithology (Finch, O'Hanlon & Dudley, 2017) or ecology (Peoples et al., 2016). Nevertheless, the use of all alternative metrics as a measure of scientific success or impact has been questioned by scientists (Robinson-Garcia, 2017; Haunschild & Bornmann, 2018). The reasoning here is that correlation results have not been replicated in all fields. Either replicability was not possible due to the dynamic nature of online records (i.e., altmetric entities), or the results obtained by one study were not shown to be significant by other researchers in the same field of studies, rendering it difficult to generalize the potential of certain altmetrics.

**Data quality**

The adaptation of standardized document identifiers (e.g., DOI, ISBN, ISSN, PubMed ID) in social media platforms and news outlets was a slow process which led to the gap Haustein (2016) mentions for the past. Most altmetric studies, datasets, services, and turnkey solutions rely on some limited list of document identifier types, meaning that media mentions without those identifiers are not accounted for in the total score. The situation has changed over time, with more recent media mentions being attributed with document identifiers. Analysis of Wikipedia references (Zagovora et al., 2020a) has shown that only 7% of references are attributed using at least one of the following identifiers: DOI, PubMed ID, PMC ID[11], arXiv ID[12], ISBN, or ISSN. The situation is a bit more optimistic for scientific publications, since many of the references without identifiers are non-academic (e.g., references to web pages). However, it remains unclear how many of them are scientific references lacking any identifiers, thus requiring further investigation.

Nevertheless, we found that approximately 10% of those references which today include an identifier were still lacking these identifiers in their early versions in Wikipedia article histories. Imagine a situation where one would want to study creators of altmetrics, i.e., in this case, Wikipedia editors who add scientific references. An algorithm that relies solely on document identifiers would assign the wrong editor for approximately 10% of all papers ever referenced on Wikipedia. Drawing upon temporal Wikipedia data, one would miss approximately 12.1% of revisions ("events" in the terminology of CrossRef Event Data[13]; see also Chapter 5 "Tools and Services") that affected these references. The facts mentioned above were obtained from the project's curated dataset (see subsection "Dynamics").

11 Also called PMCID, see details here https://www.ncbi.nlm.nih.gov/pmc/pmctopmid/

12 See details here https://arxiv.org/help/arxiv_identifier

13 https://www.crossref.org/services/event-data/



**Article-inherent factors**

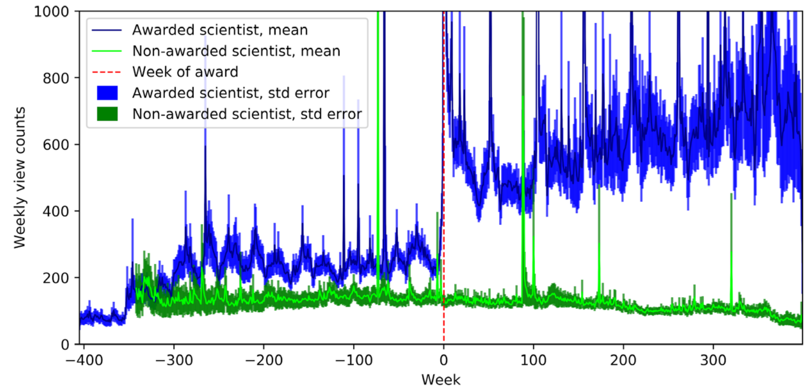
Features of scientific publications, such as the length of the title, number of authors, and collaboration patterns of authors appear to also behave differently across fields and in relation to different media mentions (Zagovora et al., 2018a). For example, publications with shorter titles in Engineering & Technology, Medical & Health and Natural Sciences received higher media attention than those with longer titles. Similar outcomes have been affirmed by Zahedi and Haustein (2018) who showed that publications with shorter titles were read and bookmarked more often by Mendeley users. In contrast, this phenomenon has not been observed in Social Sciences & Humanities (Zagovora et al., 2018a; Zahedi & Haustein, 2018).

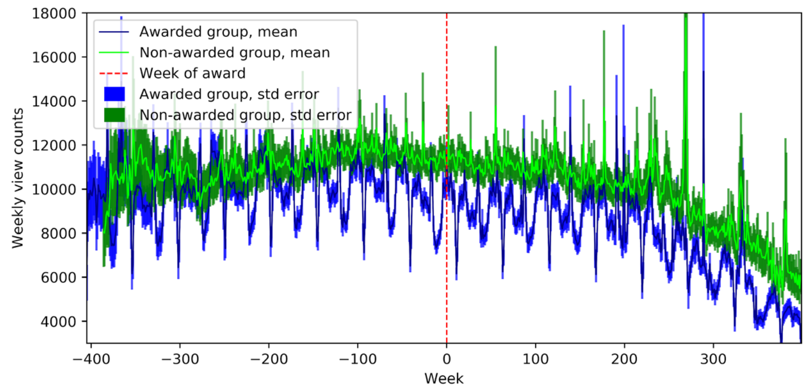
Another feature of scientific publications is the gender of its authors. Previous studies confirmed that men cite their own papers more than women do (Chawla, 2016; King et al., 2016). It is plausible to assume that scientists may also use social media to promote themselves. Moreover, Paul-Hus et al. (2015) reported gender parity in news and Twitter metrics, with disparity in blogging and news coverage. In other words, one would observe more male- than female-authored publications being mentioned at least in one news media outlet, yet the same average number of news outlets mention male- and female-authored papers. According to our project results, given the same age, the topic of the studies and citation impact, papers with a first male author are more likely to appear in Wikipedia references than papers with a female author (Weller & Zagovora, 2019). All these neat details shed light on the inconsistency problem inherited by altmetrics, too, and remind us that there may be factors which influence the specific measurable interactions in social media not directly related to scientific quality or impact. Untangling these influencing factors (e.g., for citations [Bornmann & Daniel, 2008]) is a core challenge when creating new meaningful indicators.

### Factors outside the articles

Other factors that influence altmetrics come from outside the scientific publications or even from outside the academic context. While an advantage of altmetrics is that they can capture reactions to scientific publications far quicker than traditional citation counts, their close connection to everyday communication also makes them susceptible to influence by certain (web) events or phenomena. An event is an activity that occurred in virtual or real life and led to enormous public interest in a particular topic. This event can, but does not have to be, of scientific nature. It could be a tweet by the president of a country, an economic or socio-cultural crisis, misbehavior of an employee at a multi-billion dollar company, or - as we will see below - an award nomination from the offline world. For example, Donald Trump has tweeted about immigrants and the US travel ban. As a consequence of that, many news articles have mentioned a specific scientific publication[14] that discussed the importance of diversity in working teams to the economy. Thus, the aggregated attention score of this particular paper made it the number one publication in the [Altmetric.com](Altmetric.com) collection for several months, despite it not being a peer-reviewed journal publication.

Moreover, according to our study (Wagner et al., 2018), scientific awards influence some of the altmetrics that can be obtained from Wikipedia. We tested the influence of announcements regarding field-specific award winners on attention to scientists and their research topics, with attention assessed by Wikipedia page view counts and article growth. The most notable scientific awards have a drastic influence on view counts of articles about scientists (Figure 7a), but not on those about research topics that can be associated with the award (Figure 7b). This is good news for the altmetrics community as the external event (i.e., winners' announcement) does not disrupt *metrics associated with the research topics. This is just a single example based on the influence of awards, so further systematic studies are required to determine the influence of other external events. Nevertheless, *metrics should be viewed with caution in terms of potential vulnerability due to external events.




(a) View counts for scientists (b) View counts for research topics

Figure 7: Weekly view counts for articles about scientists and research topics. "The zero point refers to the week when the scientist award was announced (dashed red line). For the non-awarded scientists, we picked a random week out of the range during which awards

14 "How Diversity Works" [https://dx.doi.org/10.1038/scientificamerican1014-42](https://dx.doi.org/10.1038/scientificamerican1014-42)

were conferred (i.e. between March 27, 2008, and October 12, 2015) as placebo points. One can see that the information demand on scientists is clearly affected by the award; however, the level of interest in research topics associated with the scientists seems to be unaffected" (Wagner et al., 2018)

### Dynamics

Temporal effects represent an additional level of complexity with respect to altmetrics. The online context that counts towards altmetrics (e.g., a Facebook post mentioning a scientific paper) is likely to disappear over time. According to Walker (2017), over 40% of tweets in his case studies were deleted within the first 2 hours following posting, and another 12.7% after three years. Academic tweets are no exception here: according to Crossref Event Data[15] and our project's preliminary results, about 9.13% of tweets with DOI links to academic publications (i.e., included in the altmetrics score) were deleted. Moreover, about 15.43% of YouTube videos that reference scientific publications in the description section are no longer accessible after 6 months (i.e., snapshot of all videos tracked by Altmetric.com as of December 7, 2017, and data collection about videos from YouTube as of June 1, 2018). About a third of the references in the English-language Wikipedia were deleted between December 2005 and July 2019 (Zagovora et al., 2020a). In comparison, the retraction of a scientific publication and the citations it includes is a rare event, according to Marcus & Oransky (2014) not more than 0.14 papers per 1,000 publications are retracted. The influence of deleted, and thus decreased, altmetrics has not yet been fully covered in the literature; one should consider recency of the aggregated data in any future altmetrics analysis since deletions can cause temporal fluctuations in altmetric counts.

With the aim of studying the dynamics of altmetrics obtained from Wikipedia, we have created a high-quality dataset with timestamps. We unfold

15 CrossRef Event Data API: https://api.eventdata.crossref.org



histories of changes of all the references that have ever existed in Wikipedia articles using natural language processing methods and data provided by the WikiWho API[16]. The dataset (Zagovora et al, 2020b) consists of information about the time of changes (i.e., modification, insertion or deletion of reference), the editor associated with that event, and lists of tokens (words) belonging to the reference at different points in time. A crowdsource testing platform is utilized to validate the quality of our method.

So far, we have seen that altmetrics are heterogeneous with respect to several important factors:

- First, scientists of various seniority levels and disciplines behave differently on social media platforms, thus producing altmetrics of different value.
- Second, even the same action types (e.g., liking) reveal different levels of intent on different media platforms.
- Third, certain article-inherent factors (e.g., title length) could potentially influence media attention, even independent of paper quality.
- Fourth, altmetrics could be affected by external events.
- Fifth, altmetrics obtained at certain points in time may be affected by data quality issues (e.g., absence of document identifiers) or by the temporal nature of web information (i.e., deleted content).

Thus, comparisons of altmetrics have to be viewed and used with caution. Furthermore, particularities of altmetrics and problems related to their mining are not limited to the factors mentioned above. Technical challenges, such as availability and accessibility of user-generated content, will be described in the following Chapter.

16 WikiWho API: https://www.wikiwho.net/

# 4. Practical challenges when collecting altmetrics data

In addition to conducting research on the impact and challenges of altmetrics as described above, another part of our project set out to create a tool to collect altmetrics data. Here, the goal was to build a piece of crawling software to collect altmetrics based on publications' unique identifiers (e.g., DOIs). The code for the resulting tool called *Metrician is available on GitHub[17] (for more information about this and other tools, see Chapter 5 "Tools and Services"). Based on this endeavor, we can report on several lessons learned in terms of data availability and other technical challenges.

The task of crawling the web for social interactions always comes with several technical and conceptual challenges. This also rings true for any web user interactions that relate to scholarly communication in the field of altmetrics. When creating our crawling software, we encountered the following main challenges and questions related to data collection and representation. We will also describe the solutions we deemed most suitable.

**1) Availability of user data**. One challenge relates to the identification of the actors who engage with scholarly content online. As we query different social media services, we obtain heterogeneous answers to this question depending on the platform structure and data made available by those services. Sometimes, one may only receive general information like time stamps for different types of interaction, or usernames. However, some services provide more detailed information like academic status, discipline or the user's field of research. To be able to analyze information about the actors in altmetrics as comprehensively as possible, raw data from the social media services' APIs should be stored in a separate database to allow the subsequent application of a variety of analytical methods.

17 https://github.com/gbv/metrics-crawler



**2) Types of interaction**. The second important challenge involves differentiating between kinds of interaction. On social media platforms there are many ways to express interest, approval or disapproval, along with other facets of human interaction. Some have a binary character, such as "liking" some content, while others are more versatile and need further analysis to grasp the meaning of the interaction, e.g., comments (see also Chapter 3 "Reliability of altmetrics"). Here, the storing of raw data is useful, but some countable values such as the number of "likes" or "bookmarks" for a certain object can be saved directly as an indexed column in a relational database so database entries can be sorted by these values. This opens the door to features like "Show the n most popular works of repository X at social media service Y".

**3) References to scholarly work.** The third question pertains to the kind of entity being referred to. The output of scientific work is embodied in a variety of types such as papers, working papers, drafts, research data or other forms that can be posted on social media. In addition, there are many ways to reference a certain work, e.g., by using unique identifiers, metadata such as title, authors, publication year or the landing page URL. With our software, we do not examine every object of the social media service in real time during creation (for example every new tweet that was posted). Instead, we import predefined lists of scientific works and then query the social media APIs at certain intervals. This dramatically decreases the required computing power and amount of transferred data. Furthermore, APIs that provide live access to all (new) objects of a certain service are often very costly. We used 3 different querying approaches to match the publications with social media posts: 1) DOI queries, 2) handle and landing page URLs queries, 3) metadata (title, author names and publication year) queries.

We selected several services to crawl for social media metrics: Facebook, Mendeley, Reddit, Twitter, Wikipedia and YouTube. We used our project results on researchers' use of social media platforms as a starting point for choosing the services to crawl (see Chapter 3 "Reliability of altmetrics"). We then added services which are frequently used by commercial providers of alternative metrics, and subsequently reduced the list based on whether a) each service had an API that provided data relevant to answering our research questions and b) returned a significant number of results.

For a test dataset of scholarly publications involving social sciences and economics (based on the repositories EconStor, SSOAR and GoeScholar from our own institutions), we ran our crawler to see how often social media interactions were found for these publications. Table 1 shows the statistics of metrics across different social media that were found for our sample of works identified by DOIs (n = 70,483), retrieved on May 16, 2019.

**Table 1. Altmetrics found for 70,483 DOIs from EconStor, SSOAR and GoeScholar.**

| **Metric type** | **EconStor** | **SSOAR** | **GoeScholar** | **Total** |
|---|---|---|---|---|
| Facebook interactions | | | | **2,905,353** |
| Reactions | 158,310 | 1,604,624 | 85,163 | |
| Comments | 46,173 | 458,135 | 29,370 | |
| Shares | 50,904 | 423,592 | 49,082 | |
| Mendeley interactions | | | | **621,430** |
| Reads | 92,974 | 141,654 | 373,156 | |
| Group posts | 5,302 | 8,344 | 14,965 | |
| Reddit posts | 163 | 2 | 19 | **184** |
| Twitter posts (since Feb 2018) | | | | **10,916** |
| Tweets | 2,774 | 205 | 903 | |
| Retweets | 5,567 | 232 | 1,235 | |
| Wikipedia citations | 158 | 280 | 1,560 | **1,998** |
| YouTube search hits | 184,873 | 645,150 | 619 | **830,642** |
| **All** | **547,198** | **3,282,218** | **541,107** | **4,370,523** |



**4) Access to altmetrics data.** When querying social media services for altmetrics data, several technical difficulties may occur. One of the most important challenges is the lack of transparency of the data collection and aggregation procedures carried out by social media services. For example, if querying the YouTube API for a certain search term returns a certain set of videos, there is no way to validate this result by checking the internal algorithms of the service that provided the data. For some of the data we received, it was not obvious how the data was collected; in fact it is rather incomprehensible. As a result, transparency of algorithms would be an aspect worth aiming for. For example, the result counts for YouTube seem highly inflated with no reasonable link to the search query, while Facebook results also supply data that is not always consistent with numbers from other services.

Implausible query results are also accompanied by technical limitations like rate limiting when fetching data from APIs, changing APIs or even APIs that were shut down. This gives rise to the need to keep up to date on the latest news for developers provided by the given service.

Conversely, crawling social media can lead to rich data when certain preconditions are met. The most important one is to have suitable information available about the identity of the work in question. While using metadata like title, authors and publication year often only leads to inaccurate results, using identifiers like DOI or local handles works best in terms of precision, especially when those identifiers can be resolved into a landing page URL of the relevant scientific work.

In our test scenario, using DOIs as search criteria for the *Metrician has proved to be successful for obtaining altmetrics (Table 2). Nevertheless, using additional search criteria enabled us to obtain altmetrics which were otherwise missed by DOI-only implementations. Table 2 shows all of the altmetrics we were able to retrieve for our set of publications from EconStor, along with the percentage of which was found using only the DOI and alternative search criteria respectively. Here, we used a publication's handle and landing page URLs as additional search criteria for most social media platforms. This was not possible for Mendeley, so we searched for metadata such as title, author names and publication years instead to find readers of publications. The matching results accounted for a substantial share (about 28%) of altmetrics found for our publication set on Mendeley. This illustrates that some platforms may not fully rely on DOIs, e.g. researchers may not use them for bookmarking on Mendeley, for instance. In such cases, additional search approaches should still be considered, despite the fact that the returned results may lack precision.

**Table 2. Share of altmetrics obtained for publications from EconStor (n=153,807) using different mining approaches.**

| | Mining for DOIs only | Mining for other criteria (handle or landing page)[18] | Paper counts with at least one altmetric |
|---|---|---|---|
| Mendeley interactions | 76% | 28%[19] | 80,686 |
| Twitter posts | 98% | 2% | 19,185 |
| Wikipedia citations | 97% | 3% | 4,659 |

**5) Use case.** The results of our data crawler can be aggregated on an individual (e.g., publication or author) or group level (research institute, funding organization or repository). For example, a visualization of the *Metrican results was implemented in the project partner's repository "EconStor". Altmetrics are displayed on individual pages of publications. An example of such a page can be seen in Figure 8 where the article received 11 bookmarks on Mendeley, 208 mentions on Twitter, and one citation in the English-language version of Wikipedia. For Twitter mentions and Wikipedia citations, a click on the gray bar below the respective altmetric counts opens a dropdown menu with further information and links to the individual tweets/Wikipedia articles, as can be seen in Figure 9.

18 ince mining Mendeley with a handle or landing page is not possible, a publication's metadata (title, authors, year) were used instead.

19 There is an intersection of returned results, meaning that the sum of the results obtained using DOI and metadata is greater than 100%.



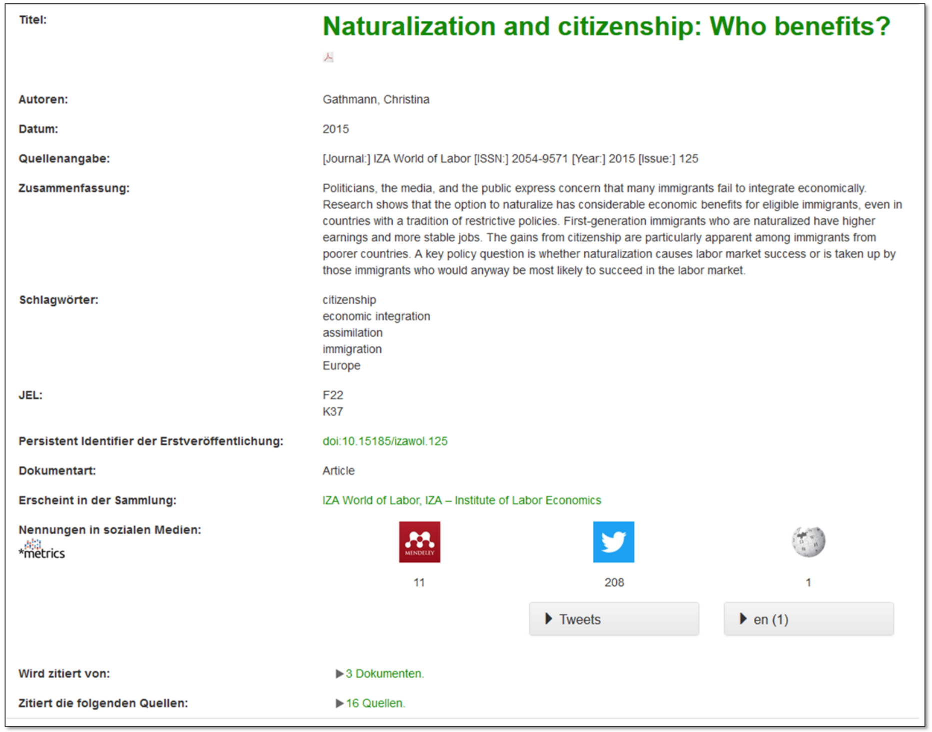



Figure 8: Article landing page with altmetrics provided by *Metrician on EconStor.

This current implementation of altmetrics in EconStor landing pages is considered to be a trial run. A first evaluation of its uptake by EconStor users was performed based on the repository's log data. However, it was not possible to verify a significant effect of the newly implemented information on users' length of stay or number of visits.


Figure 9: Additional information on individual tweets and Wikipedia citations.



# 5. Tools and services

Our own approach to creating a tool to collect *metrics data is only one example of a continually evolving ecosystem of data collection tools and data aggregators. This section showcases some of the current tools and services that can be used to capture and display altmetrics. The key facts about these tools are summarized in a short factsheet. A more comprehensive overview is available via the tab “Aggregators”[20] in the Social Media Registry (SoMeR) also created as part of our project. We have to point out that in the fast-moving research environment of altmetrics, these tools are constantly being improved and modified, and the details below show the status as of summer 2020.

## *Metrician

The *Metrician was developed within the *metrics project and can be used to collect social media metrics from several services. It is available as open source software and can be reused. Currently, there is no institution available that offers a service with this tool.

By using a DOI (or other identifier), the *Metrician can display *metrics to offer an insight into the use of a resource. Here, the focus is on altmetrics from Twitter, Facebook, Mendeley, Reddit and Wikipedia, although it is possible to extend the services to be queried (the source code is offered on GitHub. The tool will not be actively developed once the project ends).

| | |
|---|---|
| Use case | Tool for collecting data from several social media services |
| Feature | Works with DOIs, handle or ISBN, accessible via API |
| License | Open source |
| Target group | Publishers, repository managers |

20 The Social Media Registry (SoMeR) is available via: https://metrics-project.net/en/social-media-registry/

| | |
|---|---|
| URL | https://github.com/gbv/metrics-crawler<br>http://explore.metrics.gbv.de/ |

### Crossref Event Data

Crossref Event Data is a service offered by Crossref free of charge that was jointly developed by Crossref and DataCite. The events of all resources with Crossref and DataCite DOIs are recorded and stored in a database. Here, events are comments, links, shares, bookmarks, references, etc. The data can be used via an API. A large number of social media service providers are queried.

| | |
|---|---|
| Use case | Service to offer events for publications with a DOI |
| Feature | API, extensive data on each event |
| License | Event Data is a public API offering access to raw data with no fees. In the future they will introduce a service-based offering with additional features and benefits. |
| Target group | Publishers, repository managers |
| URL | https://www.crossref.org/services/event-data/ |



### Altmetric.com

The provider Altmetric.com offers various services and tools related to altmetrics. These include a free badge which can be embedded in repositories, an Explorer for institutional use, and an Altmetric bookmarklet for individual use in your browser. Some of the services are subject to a fee, while others are free of charge.

| | |
|---|---|
| Use case | Badge: Shows detailed altmetrics on individual documents (based on DOI)<br><br>Bookmarklet: Browser extension for publications' altmetrics information<br><br>Details Page API: Provides access to the metrics data associated with articles<br><br>Explorer: Provides detailed attention insights for faculties, staff and students |
| Feature | Altmetric Score: Indicator of the amount of attention a research output has received, regardless of its quality. The score is determined by an automated algorithm which uses three factors: volume, source, and author |
| License | Badge: Institutional repositories can use the badge free of charge, while others are subject to a license fee<br><br>Bookmarklet: Free browser plugin<br><br>Details Page API: Available via a variety of license types (free and paid)<br><br>Explorer: Librarians can use the Explorer free of charge, while others are subject to a license fee |
| Target group | Publishers, repository managers, institutions, researchers, funders |
| URL | https://www.altmetric.com/ |

### Plum Analytics

This service is offered by Plum Analytics, which has been part of Elsevier since 2017. It provides various metrics, most notably including usage data.

| | |
|---|---|
| Use case | Access to the several metrics data associated with articles |
| Feature | PlumX categorizes metrics into 5 separate categories: Citations, Usage, Captures, Mentions, and Social Media. |
| License | PlumX Metrics and the artifact widget is free of charge to open access journals and regional repositories, upon request and approval. |
| Target group | Institutions, repository managers |
| URL | https://plumanalytics.com/ |

### ResearchGate

ResearchGate is a social network for researchers. Here, researchers can include publications along with their full texts in their profiles. One feature is the RG Score, which quantifies the researcher's impact based on how their work is received by their peers. However, there is no documentation available on how this score is calculated[21].

| | |
|---|---|
| Use case | ResearchGate is a social network for researchers to share and discuss scientific publications |
| Feature | RG Score to measure scientific reputation |
| License | Free to use after registration |
| Target group | Researchers |
| URL | https://www.researchgate.net |

21 https://blogs.lse.ac.uk/impactofsocialsciences/2015/12/09/the-researchgate-score-a-good-example-of-a-bad-metric/



### OPERAS Metrics

The European research project HIRMEOS (High Integration of Research Monographs in the European Open Science) pursues the aim of integrating Open Access monographs into the open science ecosystem in a systematic and coordinated fashion. It developed a suite of tools for gathering and displaying metrics as part of its endeavors to offer the community tools for an easy and transparent way to collect and disseminate usage data for monographs.

| | |
|---|---|
| Use case | Normalizing identifiers; collecting and normalizing usage data from about a dozen different sources; displaying said data via a customizable Metrics Widget. |
| Feature | Highly customizable; free to use; covers some sources of particular relevance for monographs |
| License | Free to use (MIT license) |
| Target group | Organizations producing and/or hosting digital monographs, authors |
| URL | https://metrics.operas-eu.org/ |

### Dimensions

Dimensions offers a comprehensive database that collates data from various sources. The company, under the umbrella of Digital Science (as well as Altmetric.com), has access to data that opens up an interesting overview. Besides publications and their metrics, the database includes clinical trials, patents, and policy documents.

| | |
|---|---|
| Use case | A linked research data platform with a wide range of analysis opportunities |
| Feature | Extensive search and filter options; personal profiles; an API to reuse the data |
| License | The basic version is free to use, further services and analysis functions are subject to a fee |
| Target group | Publishers, repository managers, institutions, researchers, funders |
| URL | https://www.dimensions.ai |

The aforementioned tools and services provide a brief overview of the altmetrics services landscape. The *metrics market is rapidly changing, with new services and features appearing and being added by providers all the time. For each individual application, an individual decision must be made as to which tool or service best serves the given requirements. It can certainly make sense to use a tool and collect data yourself. Moreover, it may make sense to use data and adapt its presentation yourself, or to opt for fully integrated services that provide both data and presentation tools.



## 6. What are altmetrics already good for?

Our work, as well as further research on altmetrics, have shown that despite the challenges altmetrics may face, they can be successfully applied to various use cases (e.g., showcasing achievements, research evaluation, discovery of scholarly outputs or researchers; NISO, 2016). Altmetrics complement traditional metrics and can provide a more holistic picture as to whether and how scholarly outputs are engaged with beyond typical scholarly discussion channels such as journals or conferences. They also accumulate faster than traditional measures of scholarly impact, meaning that altmetrics can serve as early indicators of interest in research outputs that may also lead to future use in scholarly works (e.g. Eysenbach, 2011).

Altmetrics are better at reflecting engagement with scholarly outputs stemming from outside academia than traditional metrics such as citations. By definition, citations can only reflect the impact the scholarly work had on other scholars who also publish in scholarly outlets (analyzed by bibliographic databases such as the Web of Science) - an activity most people, even those interested in research outputs, will not do. Social media platforms are, however, open to everybody (Holmberg et al., 2014) and the barriers preventing engagement with scholarly output are very low. Evidently, liking and even commenting on a piece of scholarly work is easier and faster than writing a scholarly document for the scientific discourse in which the “liked” research output is praised and referenced. An analysis of social media’s user bases reveals who engages with scholarly work and in what ways, as was the case in our study involving YouTube (Zagovora & Weller, 2018).

In the context of YouTube, we can observe specific channels dedicated to communicating scientific knowledge to a broader audience in a semi-professional way. In spite of this, we also came across instances of individuals, apparently non-academics, who were engaging intensely with scientific papers, e.g. by reading passages to their YouTube audience. YouTube videos with particularly positive sentiments in their comments pointed us to videos that explain or visualize scientific topics, such as an introduction to the microscope or astronomical constellations. Comments on these videos value the good presentation style and level of information provided in the videos (e.g., “excellent explanation”, “you saved me before my main exam”).

One may conclude that a successful transfer of research to society takes place on social media platforms. However, this conclusion should be taken with a pinch of salt as Sugimoto and Larivière (2016) have correctly pointed out. Despite scholarly works reaching more and a broader spectrum of people on social media, the user base of (different) social media platforms should not be mistaken for society (as diffuse as this term may also be in itself). Users of (certain) social media platforms are often not representative of society as a whole (Blank & Lutz, 2017; Tufekci, 2014; Wagner et al., 2015).

However, altmetrics support researchers in finding out whether they reach their intended readership and how readers perceive, discuss and engage with literature. You can use this information to assess yourself, change strategies (e.g. mode of delivery to readers), and of course get in touch directly with parties interested in the research. Also, such kinds of analysis, which can be described as impact case studies similar to those in the UK Research Excellence Framework, provide evidence (albeit anecdotal) that research had an impact on a certain group and what this impact looked like. This knowledge can then fuel new research streams, or lead to adjustments to research, that may better express their relevance to society or other specific groups.

Altmetrics have been shown to be “tie breakers” when relevant decisions have to be made (see Chapter 2 “Perception of *metrics in the research community”). Evaluators of scholarly products take into account traditional indicators first (such as citation numbers), but if altmetrics are also available, and if they also show a significant amount of interaction, they will incline evaluators to favor  outputs with higher numbers in all *metrics. As such, altmetrics can aid selection processes and help overcome information overload, especially when having to make decisions in fields unfamiliar to evaluators.



Successful application of altmetrics requires due consideration of the conceptual differences the various social media platforms and their functions impose on the altmetrics they can produce. Depending on the user base and platform conventions involved when using platform functions, the derived altmetrics expose different meanings, even if the function has the same name, e.g. like. We can describe those characteristics as semantic richness of altmetrics. The study by Lemke et al. (2018) has shown that, in general, users take advantage of like functions more often than comment functions to express positive reactions to scholarly outputs shared on social media platforms. However, the amount of positivity towards a research product expressed by a function (e.g., retweet) also depends on the platform providing the function. Both results offer evidence that it is important to not subsume different types of social media metrics (e.g., likes, retweets, comments, shares) under one umbrella term and to not conflate altmetrics derived from functions with the same name (e.g., like) - at least not if the altmetrics are being used to reflect the user’s intent when using specific functions on a given social media platform.

Finally, social media and other online environments offer researchers new ways to share additional information about their work with a broader public audience, e.g. information that goes beyond what can typically be published. For example, we have seen instances where researchers use YouTube to share additional audiovisual material as a supplement to published research papers (one example is a YouTube video documenting the behavior of a beetle species to supplement a biology paper). Altmetrics can therefore help to capture the impact of these new types of scientific content online.

# 7. Recommendations from *metrics project

The following recommendations will help researchers, research administrators, funders, librarians, repository managers, and publishers to make use of the current state of *metrics and to utilize the related research findings. Moreover, these recommendations will highlight areas in need of improvement and propose ways to address them. The recommendations are grouped according to the four main goals of the *metrics project.

## Information about popular and major social media platforms and their functionalities

**Maintain a registry of social media platforms**
As we have seen, social media platforms are very different in terms of their characteristics and how they are used by researchers (of a certain age, role or discipline). The mix of indicators that available altmetrics aggregators offer might not suit every conceivable need. A preferable solution may therefore be to focus solely on the most applicable web-based platforms and derive data from those platforms directly. The Social Media Registry SoMeR[22] developed during the project meets this demand to describe the web-based platforms most commonly used by researchers for scholarly communication which can provide altmetrics. Platforms are analyzed in terms of their target groups, main purposes, functionality as well as accessibility to their data. Maintenance of this database will provide guidance to interested stakeholders and help them choose the most relevant sources for their scenario. SoMeR will continue to be developed in collaboration with the ROSI[23] project.

22 Social Media Registry (SoMeR): https://metrics-project.net/en/social-media-registry/

23 Reference implementation for open scientometric indicators (ROSI) https://doi.org/10.3897/rio.4.e31656



**Build services on top of Crossref Event Data**
A promising approach to collecting signals from social media platforms emerged with the launch of Crossref's Event Data service which can be used if running an own collection algorithm is not an option. In most use cases, e.g. displaying *metrics next to articles in a repository, the Event Data output is rather complex and needs additional processing steps. A middle layer created for certain typical scenarios would help practitioners get off to an easy start. That could involve giving examples of some necessary decision points (i.e. whether to sum up a platform's signals, such as tweets and retweets, or count them separately; what actions are to be considered spam; what are non-relevant Wikipedia edits and can be discarded, etc.). For each of these questions it should be possible to:
a) give typical, most recommendable answers (in a transparent way), and
b) let the user configure options based on their preferences before loading the resulting data into the local application.
Stakeholders of altmetrics should debate such issues and make solutions openly available.

## Characteristics and differences of users of social media platforms, their functionalities, and their interactions

**Address the semantic richness of *metrics**
Deeper involvement is required to fully understand what is behind some sophisticated *metrics. The semantic richness of *metrics is both a curse and a blessing: consulting *metrics from a varied set of sources reflects the variety and nuance of interactions with scholarly outputs better than merely using citation numbers, but their heterogeneity makes it harder to interpret them adequately (see Chapter 3 "Reliability of altmetrics"). Making this semantic richness easier to handle and better to understand, also for occasional users, requires environments that better visualize the background from which the numbers originate and allow access to the context surrounding these numbers rather than merely serving plain numbers without any opportunity to assess their validity (Gadd & Row-

lands, 2018) and reliability. Composite indicators cannot be the solution as they obscure the meaning of altmetrics.

However, up until now there has been a lack of research on the adequate representation of *metrics and the ability of users to understand their semantic richness. Developers of *metrics are challenged by the need to walk a thin line between providing accuracy via a high level of detail leading, presumably, to information overload, and generality via selected *metrics summaries that presumably lead to better comprehensibility and usefulness. Hence, careful selection of the *metrics information to be displayed is required, taking into account what is meaningful for the target audience of delivered *metrics (e.g., display a discipline's preferences or increase exposure to other views?). Research and development in this regard will be a challenging yet rewarding field.

**Avoid aggregations of *metrics**
A key result of our research shows that due to the variety and complexity of web-based sources and the behavior of researchers using them, it does not make sense to aggregate signals from different platforms into single numbers. One has to remember that even the same action types (e.g., like) reveal different levels of intent on different media platforms. As a result, any composite indicator will obfuscate important levels of information, which is why it is not recommended to use them despite the wish to provide clear and straightforward information.

## Perception and use of altmetrics

**Increase knowledge about *metrics for researchers**
Researchers, especially those at an early stage in their career, would benefit from systematic training on *metrics. This should include information on the broad variety of indicators and their aggregations, data sources and application areas as well as their particular strengths and weaknesses. Becoming "metric- wise" (Rousseau & Rousseau, 2017) will create fairer



conditions and a more level playing field between those already active in research who may be used to assessments, and novices just entering the arena. Informing young researchers about alternative ways of achieving and proving impact will give them the tools needed to evaluate their visibility. People who are metric-wise will also share an understanding that research assessment is complex and that there is no single metric that can be used for this.

There is an abundance of toolkits and other resources on *metrics that can support education in this regard. Apart from our SoMeR, the following resources, among others, are useful for building up an overview of the topic:

- Metrics Toolkit[24];
- Parthenos-module on Research Impact[25];
- Periodic Table of Scientometric Indicators by EC3[26];
- Leiden Manifesto for research metrics (Hicks et al., 2015).

However, knowledge about *metrics should always be linked to the researcher's contexts (e.g., career stage, discipline, use case for *metrics) in order for them to be meaningful and productive.

**Reflect critically on *metrics use**
Our research, and that of others (e.g., Wilsdon et al., 2017), has shown that the appropriate use of *metrics is not trivial and that *metrics may lead to adverse effects in the scholarly reward system (such as use of personal Impact Factors or Salami Publishing; Haustein & Larivière, 2015). Hence, it is of utmost importance to critically check for organizational

24 www.metrics-toolkit.org

25 training.parthenos-project.eu/sample-page/intro-to-ri/research-impact

26 www.elprofesionaldelainformacion.com/notas/wp-content/uploads/2018/06/tablaper3.pdf

and disciplinary applicability of *metrics prior to implementation. Also, the evaluation and selection of usage scenarios for *metrics in their own institution should be conducted carefully with all stakeholders involved, ranging from researchers and administration clerks to implementers.

Besides that, one has to avoid the generalization of results containing outliers. Outliers (i.e., research with extremely high *metrics) should be removed from the data pools and interpreted separately. That way, one can avoid the influence of extreme values on the statistical results. Outliers can be both the result of extremely valuable research output or the result of some external event (e.g., political statement that led to interest in the research topic). Moreover, the extreme interest in research output can be of a negative nature, e.g., scientific misconduct that led to discussions in social media and even to potential retraction (Shema et al., 2019).

In principle, questions should always be asked as to who benefits from a measurement of scientific output by implementing *metrics, what the goal of the measurement is, and whether a measurement makes sense at all. Responsibility for using *metrics lies with the users of the *metrics, with use cases and goals of evaluations via *metrics clarified in advance. Established evaluation practices should be critically reflected on a regular basis and revised where needed.

In that context we recommend an intensive discussion of the current evaluation practices, e.g. by using DORA, on national and international levels. A mid-term goal of such deliberations could be the German Allianz AG Wissenschaftspraxis[27] recommending its members sign DORA, or establishing other arrangements that better reflect national needs.

**Establish a national contact point for *metrics**
Judging from earlier attempts to create *metrics services and from the experiences in our own project, it becomes apparent how difficult and time-consuming the creation of reliable, transparent *metrics is going to be. Additionally, a high-level overview of the *metrics landscape along with very specialized expertise is required to provide such a service.

The establishment of a national contact point for the collection and processing of *metrics as well as the development of good practices for *metrics use would make it possible to establish long-term and quality-assured knowledge on the subject as well as data (a similar idea was recently put forward by Wouters et al. (2019)). Due to the complexity and fast pace of the *metrics landscape, joint efforts are to be preferred here since isolated stand-alone solutions will quickly become obsolete. Moreover, a joint approach would allow for quasi-standardized data collection and *metrics-building processes that are comparable across stakeholders and can serve as a basis for further developments (e.g., specialized *metrics for universities of applied sciences).

### Technical and quality issues involved in the setup of *metrics

**Improve referenceability of scholarly outputs**
The above-mentioned advice will only work if the original research output referenced and discussed on web-based platforms actually has an identifier that helps technical systems find links across entirely different platforms. This not only applies to journal articles, but also to the broad spectrum of scientific output in all its forms. The widest possible use of unique identifiers, of which DOIs seem to have been established as a commonly used system (see Chapter 5 "Tools and services"), will help to achieve altmetric results that are more comparable. Adoption and use of unique and persistent identifiers for scholarly outputs need to be increased.

**Establish good citation practices on social media platforms**
As has been established with traditional citation practices, standards and good practices for new types of "citations" on social media platforms would be a significant aid in capturing signals that reflect scholarly communication on the web. This involves properly referencing scholarly works

27 https://www.allianzinitiative.de/handlungsfelder/wissenschaftspraxis/

(using identifiers like DOIs), as well as, e.g., consistent use of functions to express positions (positive, negative or neutral stance) towards results (e.g., only use the favorite function if you want to express a positive sentiment about the content). Although the latter is a favorable goal in terms of distinct and explicit referencing behavior, it may not be applicable to the real world. However, users and developers of *metrics should monitor how researchers and other users make use of the platform functions and affordances, and how this might evolve so as to address this semantic richness of *metrics, and altmetrics in particular. This would also mean acknowledgement in most areas and disciplines where scientific communication takes place on social media. Authors of scholarly articles would also benefit from clearer referencing guidelines so they can gain easier insights into the broadness of responses to their work. This, of course, requires the development of appropriate infrastructures.

**Increase transparency about and develop standards for data collection and use of *metrics**

The heterogeneity of social media platforms and the functions they provide poses a challenge to *metrics development and their responsible use. Details on interpretations have to be untangled for every single platform, e.g. for Mendeley readership information (Stock, 2001). The same holds for the *metrics aggregators, such as Altmetric.com or PlumX, that are often opaque when it comes to what they include in their selection of platforms and how they combine *metrics in their aggregation algorithms. It has been shown that no two aggregators arrive at the same results for *metrics (in terms of coverage and intensity; Bar-Ilan, Halevi, & Milojević, 2019), which has direct implications for users of such aggregators. Here, transparency about collection and aggregation algorithms – as, for example, fostered by NISO's Altmetrics Code of Conduct (NISO, 2016) - is key to the responsible use of *metrics and informed decisions on which social media data or aggregator to use. In addition, our SoMeR increases transparency surrounding the altmetrics that can be derived from social media platforms.



Moreover, the deleted content has to be handled in an appropriate manner. While Twitter approved removal obligations for deleted content via the developer agreement and policy, other *metrics sources have not come up with such strict rules. Data distributed throughout aggregators or own aggregation solutions have to be frequently checked for relevance and pertinence. This requires the development of erasure pipelines on the data-holder side to ensure that outdated content is changed or deleted with appropriate *metrics adjustments.

However, transparency is only the first step here. The development and consequent application of standards in data collection (comparable to e.g., COUNTER Code of Practice for usage data[28]) and *metrics use is the next important landmark in web-based and social media-based evaluation practices and use cases. This would reduce the variability of altmetrics in favor of the comparability of the subjects under investigation, i.e. the results of the altmetrics analyses should be the same for each *metrics aggregator used.

**Implementations and practical experience**

Various practice groups (e.g. libraries, repository operators) should seize the opportunity to gain their own experience in the field of *metrics in their respective contexts (Coombs & Peters, 2017, Coombs et al., 2018). They could, for example, look out for trial offers to explore altmetrics products, or search for opportunities to collaborate with researchers or altmetrics providers with the aim of investigating potential implementations tailored to their own needs. We hope that the open source software *Metrician developed as part of our project (see Chapter 5 "Tools and services") will also lower the barriers for acquiring practical experience with altmetrics data. This open source solution offers the opportunity to collect social media events from different platforms and adapt the collection mode, processing and output. This allows for a somewhat simplified

28 https://www.projectcounter.org/

entry into this complex field and may spark discussions and insights that could lead to better-informed decisions as to whether it makes sense to pursue more elaborate implementations.

### Cooperate with large social media service providers for better access, and use open alternatives

If one decides to use social media or other alternative and web-based metrics as a supplement to research evaluation, solutions must also be devised to make the underlying data as transparent and reusable as possible (e.g. via open APIs and open licenses). In this case, we recommend large scholarly associations get in contact with the corresponding service providers or build up their own database of *metrics and *metrics data.

Systematic use of alternative *metrics data providers, such as Crossref Event Data and the Initiative for Open Citations[29], in conjunction with or separate from the Web of Science, Scopus, Altmetric.com, etc., will permit greater transparency of *metrics use, in turn increasing replicability of evaluations via *metrics and ensuring comparability. Moreover, this will bolster the reputation and user base of those alternative data providers, while freeing *metrics' users from the grasp of the commercial service and allowing for meaningful *metric creation on common ground.

29 https://i4oc.org/



## 8. Conclusions

The results of our project as well as the recommendations formulated in this publication are embedded in the further-reaching discussion on future assessment practices of scholarly outputs. As summarized by the Metric Tide Report (Wilsdon et al., 2015), "responsible metrics" are characterized by the dimensions of robustness, humility, transparency, diversity, and reflexivity. The *metrics project's studies provide empirical evidence attesting the significance of these dimensions (e.g. by looking into *robustness* of data over time and by revealing the *diversity* of engagement with scholarly outputs on social media platforms) and showcase practical approaches for other dimensions (e.g. by adding to the *transparency* of data collection and aggregation by sharing the code for the *Metrician tool).

We have studied the major social media platforms and their functionalities as well as their users, perception of *metrics, validity and reliability of altmetrics, and technical issues surrounding the setup of altmetrics. These studies have shown that people conducting research on altmetrics and/or using altmetrics have to accept that altmetrics are a moving target: new platforms either permitting the production of different formats of scholarly outputs or enabling engagement with scholarly outputs may arise in the future, whereas platforms that the scholarly community has used heavily to date may disappear or evolve in terms of functionality. The key challenge for all altmetrics stakeholders is to be prepared for constant change and willing to revise altmetrics' practices and platforms on a regular basis.

Besides the semantic richness altmetrics provide, which is a valuable addition to more traditional metrics, a major issue continues to limit the usefulness and credibility of altmetrics. This issue concerns the context of altmetrics as they are largely created in proprietary environments such as Twitter or Mendeley. Such platforms control access and dissemination of the data which form the basis when setting up altmetrics. For example, it is unclear whether all public tweets are potentially accessible via Twitter or whether only a portion of the entire tweet set is accessible to third parties. This is a bottleneck that impairs transparency, scrutinization and sharing of data, leading to reduced reproducibility of research - something which altmetrics research has in common with other forms of social media studies. The same challenges arise when using altmetrics aggregators, such as [Altmetric.com](Altmetric.com) or PlumX. Due to growing competition, they are increasingly less transparent about their algorithms used to search for and collect altmetrics' signals, even if they comply with NISO's Code of Conduct for Altmetrics Data Quality. Important initiatives such as I4OC[30] or Crossref Event Data have set up open alternatives to proprietary *metrics providers and aggregators, but a more concentrated approach is required to change current practice and increase uptake of such alternatives among stakeholders of the research enterprise and of *metrics.

In addition to those pressing issues that affect *metrics research as a whole, further work is needed to better understand the nature of altmetrics as well as their potential and pitfalls. Only if we know what altmetrics can be used for (and what not), can we use and develop altmetrics - any kind of *metrics - in a responsible way. Turnkey solutions may be easy (and cheap) to implement, but they still need to be checked carefully to determine whether they are suited to the intended purpose. Thus, efforts for setting up *metrics services and gathering data should be pooled to be more efficient with time and resources and to guarantee a broad applicability (Coombs & Peters, 2017).

Reflections on the value of altmetrics are also embedded into vibrant discussions about general academic values and the broader academic system (visible, e.g., in the reports of the EU Expert Groups on Altmetrics and on Indicators for Researchers' Engagement with Open Science[31]). We believe this also highlights a key opportunity of altmetrics: they can inspire and encourage the scholarly community to discuss what scholarly communication should look like in the future and how scholarly work should be assessed. This, in turn, could hopefully kick-start the long-overdue revision of the scholarly reward system and appropriate *metrics use cases.

## Acknowledgements

This research was supported by the Deutsche Forschungsgemeinschaft, DFG, project number 314727790. We would like to thank all individuals and institutions that supported our work. We explicitly wish to thank: the project members Martin Fehrensen, Maxie Gottschling, Andreas Krausz, Michael Kusche, Diana Lindner, Athanasios Mazarakis, and Maryam Mehrazar; our student assistants Julian Gill, Christine Gujo, Oliver Hahn, Marni Hanke, Tara Morovatdar, and Moritz Wiemann; the team at Econstor, namely Wolfgang Riese, Olaf Siegert, and Jan Weiland for their support in implementing *Metrician in Econstor; the GoeScholar team, the team at SSOAR; additional colleagues at GESIS, notably Kenan Erdogan, Roberto Ulloa and Fabian Flöck for their insights into using WikiWho to mine Wikipedia references; Altmetric.com, who helped our project tremendously by granting it free access to the Altmetric Explorer and their entire database for the duration of the project; Joe Wass from Crossref Event Data and Martin Fenner from DataCite for their insights into the technicalities of altmetrics' providers; Nicholas Fraser, Andrew Rennison, and Birgit Schmidt for their highly valuable feedback during this report's creation; all of the participants in our surveys, interviews, experiments, and workshops. We would like to thank DINI for their support in shaping the project proposal, their ongoing interest in the project, and the opportunity to publish this brochure.

30 [https://i4oc.org](https://i4oc.org)

31 The Report "Next-generation metrics: Responsible metrics and evaluation for open science" of the Expert Group on Altmetrics is available via doi:10.2777/337729. The report "Indicator frameworks for fostering open knowledge practices in science and scholarship" of the Expert Group on Indicators for Researchers' Engagement with Open Science is available via doi:10.2777/445286.

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# Appendix B — User Studies in the *metrics Project - Demographics

| | Survey I | Interviews | Survey II | Choice Experiments |
|---|---|---|---|---|
| Number of participants | 3,427 | 9 | 2,083 | 248 |
| Gender | | | | |
| Female | - | 22% | 31% | 30% |
| Male | - | 78% | 69% | 70% |
| Other | - | 0% | 0% | 0% |
| Academic Rank | | | | |
| Assistant/Associate/Full professor | 44% | 0% | 58% | 50% |
| PhD student/research assistant | 32% | 78% | 16% | 20% |
| PostDoc/senior researcher | 19% | 22% | 17% | 22% |
| Other | 5% | 0% | 9% | 8% |
| Country of affiliation* | | | | |

| | | | | |
|---|---|---|---|---|
| Germany | 51% | 78% | 31% | 35% |
| USA | 10% | 0% | 14% | 11% |
| United Kingdom of Great Britain | 5% | 0% | 6% | 6% |
| Italy | 5% | 0% | 5% | 8% |
| France | 3% | 0% | 4% | 3% |
| Other | 26% | 22% | 40% | 37% |
| Discipline | | | | |
| Arts/Humanities | 2% | 0% | 1% | 2% |
| Economics | 60% | 56% | 71% | 61% |
| Engineering/Technology | 4% | 22% | 2% | 3% |
| Law | 1% | 0% | 1% | 1% |
| Life Sciences | 2% | 22% | 1% | 3% |
| Medicine | 0% | 0% | 0% | 0% |
| Physical Sciences | 1% | 0% | 0% | 0% |
| Social Sciences | 23% | 0% | 18% | 21% |
| Other | 7% | 0% | 6% | 9% |

*Shown distinctly are the five most frequently selected countries from both surveys.

## Aufnahmeantrag für die Mitgliedschaft in DINI e.V.

(auch online unter https://dini.de/mitgliedschaft/mitgliedsantrag/)

**Angaben zum Antragsteller:**

Name: ..............................................................................................................

Vorname: ..........................................................................................................

Sind Sie Bevollmächtigte/r der antragstellenden Institution? Ja ☐ Nein ☐

Institution: .......................................................................................................

URL der Institution: ..........................................................................................

**Die antragstellende Institution ist Mitglied in:**

☐ AMH ☐ dbv ☐ ZKI ☐ Wissenschaftseinrichtungen und -organisationen

Anzahl der Beschäftigtenvollzeitäquivalenz (BVZÄ): ...........................................

**Weitere Angaben:** (entweder zu Ihrer Person oder der Institution):

Anschrift: .........................................................................................................

Straße, Nummer: ...............................................................................................

PLZ, Ort: ..........................................................................................................

Telefon: ...........................................................................................................

Fax: .................................................................................................................

E-Mail-Adresse: .................................................................................................

**Wer soll Mitglied werden?**

☐ Hochschule ☐ Institution ☐ Fachgesellschaft ☐ Sie selbst

**Welche Art der Mitgliedschaft wünschen Sie?**

(Zur Definition der Mitgliedschaft siehe Satzung § 3)

☐ Ordentliches Mitglied ☐ Assoziiertes ☐Mitglied

**Bemerkungen:**

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DOI: 10.18452/22242

**Publisher:** Deutsche Initiative für Netzwerkinformation e. V.

**Contact details**

DINI – Deutsche Initiative für Netzwerkinformation e. V.

Geschäftsstelle | c /o Niedersächsische Staats- und Universitätsbibliothek
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**Last updated:** December 2020

DEUTSCHE INITIATIVE FÜR NETZWERKINFORMATION E. V.